

A Correction.

IN my letter *re* "Birds attacking Butterflies and Moths," in NATURE for March 6 (p. 415), there occur the words, "I conclude, therefore, that they were last year's birds, which knew and disliked *D. limniace*." There is some slip here, for what I meant to say was, "I conclude, therefore, that last year's bird knew and disliked *D. limniace*." This, it will be seen, agrees with the context; I only used one Babbler last year, and offered *D. limniace* to this only.

F. FINN.

Indian Museum, Calcutta, March 27.

SOME SCIENTIFIC CENTRES.

IV.—THE HEIDELBERG PHYSICAL LABORATORY.

MOST travelled Englishmen are doubtless acquainted with the ancient town of Heidelberg, so famous for the beauty of its situation and the grandeur of its ruined castle. But far fewer know the charms of the long and romantic valley of the Neckar, at the almost sensational exit of which, from the Odenwald into the level plain of the Upper Rhine, Heidelberg stands. So also it is true that while most educated people connect Heidelberg with the great names of Kirchhoff and Bunsen and their epoch-making discoveries in spectrum analysis, it is only the special students who know how large in extent and how important in result and example is the work which has steadily gone on for many years in the physical laboratory in the Friedrichsbau.

Its small beginnings in the middle of the last century are marked by the name of Kirchhoff scratched on the window of what is now the private room of the senior assistant. From this window one may look out over the Rhine plain towards busy Mannheim, as Bunsen and Kirchhoff did one night when a fire was raging there, and they were able by spectroscopic examination of the flames to ascertain that barium and strontium were present in the burning mass. But the same window also looks across the Neckar to the Heiligenberg, along the slopes of which runs the "Philosophers' Walk," the chief of the many paths among the wooded hills around the town, which the two friends were wont to traverse in their daily "constitutional." Bunsen is known to have said that it was during such walks that his best ideas came to him. One day the thought occurred, "If we could determine the nature of the substances burning at Mannheim, why should we not do the same with regard to the sun?" But people would say we must have gone mad to dream of such a thing." All the world knows now what the result was, but it must have been a great moment when Kirchhoff could say, "Bunsen, I have gone mad," and Bunsen, grasping what it all meant, replied, "So have I, Kirchhoff!"

Kirchhoff's four-prism spectroscope, together with other apparatus of his, is preserved in the collections of the Laboratory, and well deserves the almost reverential awe with which it was examined by a certain foreign professor, who protested that objects of such historic interest should be kept in a fire-proof safe.

Kirchhoff, who in his later years suffered much from ill health, left Heidelberg in 1875 on his appointment as professor of theoretical physics at Berlin, where, by the way, he had no official laboratory, and carried on his experimental work (*e.g.* the research on the conductivities of the metals for heat and electricity) in the laboratory of his friend von Hansemann. His successor at Heidelberg was his former pupil, Quincke, who has been professor there ever since, and is now the "doyen" of German physicists, both by length of service—for though only sixty-seven he has been a professor for more than forty years—and by the amount and variety of his scientific work. It is true that this work has not been of the kind that gets into the newspapers, but the real students will certainly value it none the less on that account, and even the beginner in science has heard of

"Quincke's Interference Tube" and his standard measurements of capillary constants. English students may well take some special interest in Quincke, for his personal relations with English men of science (*e.g.* Lord Kelvin and Sir Henry Roscoe) have been particularly close; he is never tired of dwelling with admiration on the achievements of Young, Faraday and Kelvin—and in the case of Young in particular of vindicating his priority in respect of many of the ideas in light and sound often regarded as original to Fresnel and Helmholtz—and nowhere have his own researches been more highly valued than in this country, as is shown by the long list of Universities (Cambridge, Oxford, Glasgow) and learned societies (from the Royal Society downwards) which have conferred their honours upon him.

Georg Hermann Quincke was born at Frankfort a. O. in 1834 of partly Huguenot extraction. One who has seen the diagrams, with circles worthy of Giotto, which he draws on the blackboard, or had experience of his apparently intuitive knowledge of the possibilities of the most various materials and mechanical processes, might well be inclined to regard this kind of power, so valuable to the physicist, as an inheritance from some skilful Huguenot ancestor. From 1852 onwards he studied at Berlin, and then for a time at Königsberg, attracted thither (with others, such as Kirchhoff and Clebsch) by the fact that F. E. Neumann was delivering the only course of lectures on mathematical physics then to be heard in Germany. Neumann's mathematical and experimental genius had considerable influence on Quincke, and it was here that the profound interest in molecular physics which has dominated his life-work was aroused in connection with the theory of capillarity. But Neumann allowed his pupils too little scope for originality, and Quincke removed to Heidelberg, where (in 1854) Kirchhoff had just been appointed professor of physics. Under him Quincke carried out (in 1856) his first physical research, an investigation of the lines of flow of an electric current from one point to another of a metal plate. With a plate made of adjoining semicircles of copper and lead, Kirchhoff's law of the refraction of currents was confirmed, *viz.* that the tangents of the angles of incidence and refraction are in a constant ratio, though, curiously enough, this ratio was not found equal to that of the conductivities of the two metals, as the theory requires, but only about half as great. During this time—in which Matthiessen and Roscoe were among his fellow students—Quincke also worked much with Bunsen, especially in gas and mineral analysis, and, indeed, his first published paper was on the red and grey gneiss of the Erzgebirg (1856). Doubtless the association with Bunsen did something to cultivate Quincke's native faculty for the ingenious adaptation of the simplest materials, of which more hereafter.

From Heidelberg Quincke returned to Berlin, "promoviert" in 1858, became "Privat docent" in 1859, in 1860 was appointed professor at the Royal Prussian "Gewerbe Akademie" and in 1865 "ausserordentlicher" professor at the University of Berlin, posts which he held till 1872. His courses of lectures included the only one in mathematical physics then given in Berlin. But as regards original work the young professor was much hampered by the fact that he had neither stores of apparatus nor even a decent library of scientific literature at his disposal. In both respects he was much aided by his friend Wilhelmy (of invert sugar fame), who possessed a good deal of apparatus brought from Paris, and by Mitscherlich. Before this Mitscherlich had introduced him to G. Wiedemann, and a beautifully kept juvenile note-book had led to his drawing the figures for some of Wiedemann's publications. How well he was capable of such work will be clear to all who have seen his lithographed sheets of instructions for practical work in use in his present laboratory, with their admirable diagrams.

With Wilhelmy's apparatus, and much which he constructed for himself, often out of the simplest materials, he was able to exhibit many of the chief optical experiments which could at that time be seen nowhere else out of Paris, and to inspect which some of the leading men of science in Berlin, such as the mathematician Kronecker, were glad to visit him. To take but one instance of his ingenuity in devising efficient substitutes for the complicated and expensive forms of apparatus generally used, we may mention his method of constructing a Fresnel's double mirror. Two equal plates of black glass are fastened to a suitable wooden slab by means of four wax pellets, two under the corners of the adjacent edges, and one each under the centre of the opposite ends of the plates. If now a thin sheet of glass is laid over the whole and gently pressed down in the centre, the two glass plates become inclined to one another at slightly less than 180° , forming—*experto crede*—a perfect Fresnel's mirror. In this way the students in his present "Praktikum" construct this piece of apparatus for themselves as required.

Quincke's settlement in Berlin was signalled by his discovery of the "Strömungsströme," or electric currents produced by the flow of liquids past solid walls, which is the inverse phenomenon to the "elektrische Fortführung," or transport by an electric current of suspended particles through liquids in narrow channels. This he examined in an extensive research, leading to the conclusion that both phenomena were due to electrification by contact of the liquid with the solid wall or the suspended particles. The range of cases in which electrification is produced by contact of dissimilar substances was thus largely increased, and *inter alia* it was shown that a bubble of air in contact with water carries a negative charge, a result which accounts for the interesting discovery of Lenard that in the neighbourhood of Alpine waterfalls the air is invariably strongly negatively charged.

To this same period belong two extensive series of researches in optics and capillarity respectively. The optical investigations, recorded in close upon a score of lengthy papers in *Poggendorff's Annalen*, deal with the most difficult questions connected with the optical properties of metals, the researches of Cauchy, Stokes and Jamin, and the behaviour of polarised and diffracted light in general. From among the results obtained we have only space to mention the discovery of "lamellar diffraction,"¹ the proof that neither Jamin's law of polarisation by reflection nor Stokes's theory of the polarisation of diffracted light is in accord with all the facts, the considerable addition to the theory of the diffraction grating, and the startling deduction from some of the work of the fact (long afterwards confirmed by Kundt and others) that the refractive index of silver and gold for sodium light is less than 1, a result which of course means that light travels faster through these metals than in air. It is an interesting fact that these researches were originally prompted by the hope of penetrating more deeply into the secrets of the molecular constitution of matter. Many of them were carried out by the help of thin metallic films deposited on glass. But these very films did not a little to show that capillary phenomena were likely to be more fruitful in this direction. One of the most elegant of modern researches is that in which (1869) he used a wedge-shaped film of silver deposited on glass to measure the range of molecular attraction, by determining the thickness of the silver film through which the capillary action of the glass on water in contact with the plate just vanished. The result was that the radius of the sphere of action of the molecules is about 50μ (*i.e.* about one-tenth of an average light-wave). This was the first effective attack on this profoundly in-

teresting problem; the method remains the least exceptional yet devised, and the result has been confirmed by the later researches of Sohncke (1890),¹ though Röntgen and others, by means of more questionable methods, have found a value many times smaller.

It will be convenient to speak of the capillary researches in a general view presently, but mention must be made here of the well-known acoustic interference tube. The invention of this (1866) was due to a case communicated to him by a doctor, in which a patient, whose hearing was being tested by sounding a tuning-fork at the end of a rubber tube leading to his ear, was found to hear better when the tube was pinched. This was the first of several forms of acoustic interference apparatus devised by Quincke, which have been used by his pupils for investigations on the velocity of sound under various conditions, recently, for instance, in air at high temperatures. From this research it appears that the ratio of the specific heats for air falls from 1.40 at 0° C. to 1.34 at 1000° C.

In 1872 Quincke was appointed to the chair at Würzburg, whence he was called in 1875 to fill Kirchhoff's place at Heidelberg. His work there has been marked by a long series of electric and capillary researches, and by a great increase both in the efficiency of the laboratory and in the number of students. Among those who have studied under Quincke or worked in his laboratory may be mentioned Profs. Lenard (Kiel), Braun (Strassburg), W. König (Frankfort), Max Wolf (Heidelberg), Precht (Hannover), and Willard Gibbs and Michelson of America. The work is still hampered by want of room and by the antiquated character of the building, which compares but poorly with the "Paläste der Physik" recently erected at several of the German Universities. But men are more than buildings, and Quincke has shown astonishing ingenuity in utilising the space and means at command to accommodate the 120 students who attend his "Praktikum."

It is perhaps in association with the practical work of his laboratory that Quincke is seen at his best. He maintains a constant interest in the doings of his "Praktikanten"; no student is too dull nor any experiment too simple to enlist his personal attention. His research students find him unfailing in advice and assistance of the most helpful kind. If he is on occasion "heftig," it is only to become kinder and more helpful than ever. He gives his time ungrudgingly to his "Colloquium" and "Seminar." In the latter (held in the summer Semester) he lectures at length on some classical research, the practical work in connection with which is then carried out by the students, and the theory reproduced and results recorded in full for his approval and criticism. The Colloquium (in the winter Semester) is a small society for the discussion of current physical research. Here one learns to admire alike the patient consideration he shows the "Vortragender" (even if the latter happen to be a foreigner stumbling through his task in the most deplorable German), the independence and originality of his own outlook on current theories, and his extraordinarily wide acquaintance with both the older and the most recent literature of physics.

His lectures deal with an unusually wide range of topics, and are illustrated, not merely by a large collection of diagrams mostly drawn, and where necessary coloured, by his own hand, but also by many experiments rarely exhibited elsewhere. To quote a few instances almost at random, it is not often that one has the opportunity of seeing Cornu's hyperbolas (formed by reflection of monochromatic light from the surface of a bent glass strip), or water spread out in a capillary film on the surface of mercury, or experimental proof of the fact that super-

¹ Precht (*Wied. Ann.* lxi.) believes he has found a similar phenomenon in the case of Röntgen rays.

¹ And by the investigation of R. Weber (1901) on oil films (referred to in Prof. Rücker's recent presidential address), which was carried out in Quincke's own laboratory.

saturated water vapour only condenses in presence of suitable nuclei, or the production of double refraction by electrostatic stress (Kerr effect) in liquids, or Faraday's pretty experiments on the electrolytic action of the current from a frictional machine, or the beautifully ingenious demonstration, by manometric measurement of the pressure of an air bubble between the plates of a condenser immersed in an insulating fluid, of the pressure perpendicular to the lines of force in the electric field and its relation to the difference of potential between the plates. This last experiment was originally devised by Quincke in connection with an important research on the dielectric constant (sp. ind. cap.) of liquids, which he measured in three different ways—the ordinary "capacity" method, the measurement of the attraction between the plates in air and in the liquid (*i.e.* of the force parallel to the field), and, as just mentioned, of the pressure perpendicular thereto. The three methods yielded results which were, on the whole, in very satisfactory agreement

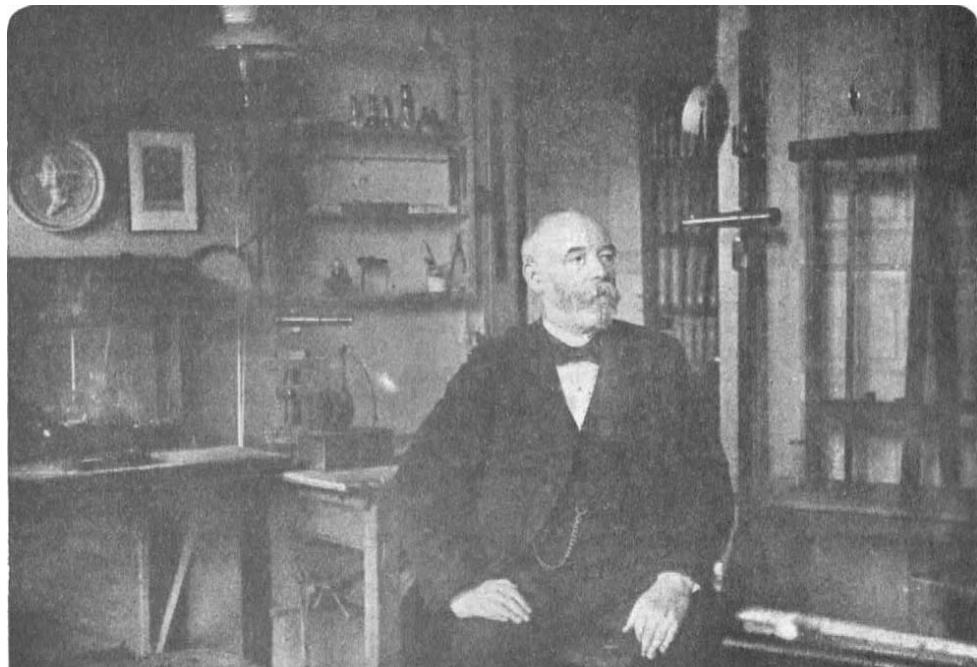
with one another and with Clerk Maxwell's theory, *e.g.* for CS_2 2.64, 2.67, 2.74 (square of refractive index for D line 2.69).

This was only one of a long series (1880-1888) of electric and magnetic researches. These dealt, *inter alia*, with the alteration in elasticity, volume and refractive power produced by electrification ("electric expansion") and electrostatic double refraction, with the suggestion that the latter may be explained by the former. Deserving of especial mention is the discovery of the changes in level of magnetic (and diamagnetic) liquids contained in the capillary limb of a U-tube placed in the magnetic field.

These changes are due to the difference of the "magnetic pressures" perpendicular to the lines of force in the liquid and the surrounding gas (compare the electric case above); they are proportional to the susceptibility of the liquid and the square of the field strength, and if the latter be independently determined, the susceptibility is deduced. By varying the gas in contact with the liquid, the susceptibility of gases may be measured. A method similar in principle is applicable to solids in the form of wires or electrolytic deposits on suitable rods. When once the susceptibility of suitable liquids (ferric and manganese chlorides are among the best) has been determined, the method can be used with great advantage to measure the strength of magnetic fields.

All this opened a wide field of research, but space forbids us to dwell on the interesting developments respecting "atomic magnetism" and other points.

Quincke is probably most widely known by his researches in capillarity, which have been of the most extensive and laborious kind. For the fundamental liquids, as we may call them, *i.e.* water and mercury, he has made great use of the methods of flat drops, and of air bubbles in the liquid, and therewith found values of the surface tension somewhat higher than those obtained by himself and others in other ways, in particular (for water) by the well-known capillary-tube method. He regards these higher values as the more probable, and concludes that the angle of contact of water and glass is not zero, as usually assumed, and therefore the water does not rise so high in capillary tubes as it would if the angle actually vanished. He has confirmed this by devising methods for measuring this angle of contact both on flat surfaces and in capillary tubes, and thus shown that for water and glass the angle may be 20° or so. He has also proved how sensitive the angle is to slight and often imperceptible changes in the condition



Georg Quincke

of the surface. For water on cleavage surfaces of mica, for instance, it varies from 0° to 30° or more, according as the surface is quite fresh or has been exposed for shorter or longer periods to the air. By this principle of the variation of the angle of contact, and consequently of the size and appearance of small drops of liquid (water, mercury) deposited on a surface different parts of which are in imperceptibly different conditions, he has explained the formation of the curious "breath figures" and of Daguerreotype photographs. Daguerre discovered these through the accident of having left some of his silver iodide plates, which he had until then been unable to make permanent, in a cupboard where some mercury had been spilt. The vapour deposited itself in different-sized droplets on the different parts of the plate and gave a picture which could be made permanent.

The very extensive series of researches Quincke has made on salt solutions lead to the general result that the

surface tension of such solutions increases with greater concentration by a term proportional to the number of equivalent weights of salt in the solution. For fused solid substances he has measured the surface tension by the methods depending on the weight of falling drops, and on the size and form of drops formed on a flat surface. Employing, then, a quantity a^2 which he calls the "specific cohesion" of the substance (defined by $a^2 = 2$ [surface tension]/ density), he found the remarkable result that ("to a degree of approximation closer than that which holds good for Dulong and Petit's law of atomic heats") all pure substances fall into one or other of six classes the specific cohesions of which are in the ratio of $\frac{1}{2}$ (e.g. phosphorus, sulphur, bromides, iodides): 1 (e.g. Hg, Pb, chlorides, nitrates, sugars): 2 (e.g. water, Ag, carbonates, sulphates): 3 (e.g. Zn, Fe): 4 (K): 7 (Na). It may be noted that a^2 measures the capillary attraction of a fluid sphere of unit radius on unit mass at its surface. That this quantity for various fluids is proportional to 1, 2, 3 . . . is in remarkable contrast to the fact that gravitational attraction is independent of the nature of the substances involved.

One of Quincke's most interesting and characteristic researches relates to the motions produced in drops clothed with oil films when an alkali is brought into contact with the oil, forming soap, which locally disturbs the existing surface tensions and causes a movement of the drop. Quincke sees in this the explanation of the movements of protoplasm. To quote his own words, "Ich glaube gezeigt zu haben, dass der Zellinhalt (das Protoplasma und der Zellsaft) jeder Pflanzenzelle von einer lünnen Oelhaut bekleidet ist: dass dünne Oellamellen mit festem und flüssigem Eiweiss die Plasmamasse durchziehen, und dass durch Einwirkung des alkalischen Eiweiss auf das oelsäurehaltige Oel periodisch 'Eiweissseife' entsteht, aufgelöst und an der Grenze von Oel und umgebender Flüssigkeit ausgebreitet wird. Diese periodische Ausbreitung der wässrigen Lösung von Eiweissseife gab dann die physikalische Erklärung der im Innern der Pflanzenzelle beobachteten Bewegungerscheinungen." Quincke's most recent researches relate chiefly to his favourite problems of molecular physics, but are, for the most part, still unpublished.

Reference has already been made to the Heidelberg "Praktikum," or course of practical physics, for which Quincke has devised many ingenious forms of simple and cheap apparatus, which are yet capable of giving surprisingly good quantitative results. Here one may see an optical bench which, though chiefly made of a half-metre scale and some cork, sealing wax and glass strips, yet enables the student to make all the usual measurements with mirrors and lenses, without dark room, and with an accuracy equal to that obtainable with apparatus many times larger and more expensive. Again, Quincke has invented a form of reflecting galvanometer¹ which costs some fifty shillings in all, but is sufficient for all ordinary electric measurements, not merely for learners, but also for research students. Want of space forbids us to tell of the almost innumerable devices for solving just those problems which confront so many of our science teachers in England at this moment which the Heidelberg laboratory contains. A word may be spared for two seeming trifles which are astonishingly useful. One is the lidless box used as a seat, giving three different heights, according as it is placed on its short, long or open side. A few of these can be combined with a screw clamp or two in endless ways to serve as supports for apparatus, &c. The other is a form of trestle² (with the two slant legs at one end replaced by one vertical one), which is very convenient as a support for pendulums and other such apparatus.

¹ This, together with Quincke's invaluable "Cathetometer Microscope," is visible on the table behind the Professor's right arm in the photograph reproduced herewith.

² Visible on the right of the photograph.

It is much to be hoped that Prof. Quincke may see his way to publish his laboratory notes in book form, and if he would accompany such a book with directions for carrying out what a witty Heidelberg student described as "Quincke's cork-wax-pfennig system," he would be conferring a boon on many students and more teachers. But we fear it is hardly likely that the claims on his time as teacher and investigator will allow opportunity for this to be done.

EMILIEN JEAN RENOU.

M. RENOU was born at Vendôme, March 8, 1815, and, naturally, went to the Lycée there. He entered the Ecole Polytechnique in 1835 and later the Ecole des Mines, where he studied under Élie de Beaumont. He subsequently visited German universities for two years, especially the lectures of Gauss at Göttingen.

From 1839-42 he was attached to the Scientific Commission of Algeria and published a "Description Géologique de l'Algérie." In 1846 he was directed to collect all the information as to Morocco which he could find, and the result was a valuable work, "Description de l'Empire du Maroc." He made a second visit to Algeria, at his own expense, to verify previous geographical determinations.

In 1850 he resolved to devote himself almost exclusively to meteorology, and he was one of the founding members of the Société Météorologique in 1853. He has published numerous papers in its *Annuaire*s. He acted as its secretary for eleven years, not consecutive, and no less than four times was elected to fill the office of president.

In 1868 he was one of the members of a committee, under the presidency of Charles Ste. Claire Deville, for the organisation of the observatory of Montsouris. After the events of 1870-72, this establishment was placed under M. Marié Davy, and M. Renou had to leave.

In 1872 he was officially appointed director of a laboratory for meteorological research, an office which he held until his death. This establishment was first located at Choisy le Roi, but in a few months it was moved to Parc St. Maur, to a locality rented by M. Renou. On the official establishment of the Bureau Central de Météorologie, M. Renou's station was selected as the central station for the climate of Paris, and the instruments were moved to a plot of ground which was assigned to the Bureau, and where they now remain. M. Renou has contributed to the *Annales* of the Bureau three important papers on the climate of Paris.

M. Renou deservedly received many honours, the principal being Legion of Honour, Chevalier (1847), Officier (1884), Officier de l'Académie (1873), and Officier de l'Instruction Publique (1891).

He died on April 6 at Parc St. Maur at the age of eighty-seven; and he has bequeathed his large library to the public library of his native place, Vendôme.

R. H. S.

NOTES.

THE first of the two annual soirees of the Royal Society will be held on May 14. This is the soiree to which gentlemen only are invited.

THE meeting of the Paris Academy of Sciences on April 14 was adjourned as a sign of respect for the late Prof. A. Cornu, whose untimely death was announced by the president in the following words:—"The Academy of Sciences has suffered a great loss. Prof. Cornu died on Friday, carried away rapidly by a disease which no one could foresee would terminate so sorrowfully. Our colleague was relatively young; he entered the Ecole Polytechnique in 1860 and was nominated a mem-